NORTH AMERICAN SPRING-TAILS OF THE SUBFAMILY TOMOCERINÆ.

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Collectors who are not especially interested in Collembola often have their attention attracted by large and agile specimens of *Tomocerus*. The species of this genus are among the largest "spring-tails" that we have, attaining often a length of 5 mm. They occur under loose bark, in damp, decaying logs, in moss, and generally on the ground, under dead leaves, logs, or other objects. Some species are lead-colored before they lose their scales; others are purplish or blackish, and the scales give the insects a metallic appearance, with more or less iridescence. After the scales are lost the body-color is frequently yellow, but is highly variable, even in individuals of the same species.

The forms of North American Tomocerinæ discussed in this paper—few in number, but all that are known at present—are as follows:

Tomocerus flavescens Tullberg.
Tomocerus flavescens Tullberg, var. *separatus*, new variety.
Tomocerus flavescens Tullberg, var. *americanus* Schött.
Tomocerus flavescens Tullberg, var. *arcticus* Schött.
Tomocerus bidentatus, new species.
Tomocerus vulgaris Tullberg.
Tomocerus minor Lubbock.
Tritomurus californicus, new species.

T. flavescens, *vulgaris*, and *minor* are common and well known in Europe. *Tritomurus* is a rare and little-known European genus, to which belong several specimens that I have received from California.

For much of my material I am indebted to many collectors, whose names appear beyond, and especially to Dr. A. D. MacGillivray. All specimens recorded without a collector's name were collected by myself. The ownership of specimens is designated in parentheses, the omission of which indicates that specimens are contained in my private collection at present. Cotypes have been deposited in the

United States National Museum, Washington, District of Columbia, and in the Museum of Comparative Zoölogy, Cambridge, Massachusetts.

The subject here considered was studied in the entomological laboratory of the University of Illinois, of which it forms contribution No. 35.

Subfamily TOMOCERINÆ Schäffer.

Tomocerinæ SCHÄFFER '96, p. 177.—BÖRNER '06, p. 161.
Tomocerini SCHÄFFER '97, p. 35.—BÖRNER '01, p. 60; '06, p. 161.—ABSOLON '03, p. 108.

Eyes twelve or none. Antennæ four segmented; third segment much longer than the fourth; last two segments subsegmented. Prothorax reduced, membranous. Mesonotum covering pronotum, but not projecting over the head. Tibiotarsi one or two segmented; clavate tenent hair present or not. Both claws present. Unguis pseudonychiate, with basal folds and simple (not double) teeth. Third abdominal segment longer than the fourth. Dentes three-segmented, with stout basal spines; mucrones long, subcylindrical. Anal segment with three cerci. Scales present, with longitudinal ridges and transverse striæ. Two genera, as follows:

Eyes twelve; tibiotarsi two-segmented; clavate tenent hair present. *Tomocerus*, p. 452.
Eyes absent; tibiotarsi one-segmented; clavate tenent hair absent. . *Tritomurus*, p. 469.

Genus TOMŌCERUS Nicolet.

Tomocerus NICOLET '41, p. 67.

There are six eyes on each side of the head (fig. 1). The antennæ (fig. 2) are long, but exceed the body in length in only a few species of the genus. The short terminal antennal segment is often absent through mutilation; this segment and the third are subdivided into short rings, which in the latter segment often number one hundred and fifty or more, except in young individuals.

FIG. 1.—TOMOCERUS FLAVESCENS, VAR. ARCTICUS. EYES OF RIGHT SIDE. × 320.

The leg, in Collembola, consists primarily of seven segments, five of which were formerly termed, respectively, coxa, trochanter, femur, tibia, and tarsus, as in other insects. Börner's ('02) comparative studies of the segmentation of the legs of myriopods and insects have led him to apply the term "tibiotarsus" to the so-called tibia of Collembola and to adopt de Meijere's ('01) term praetarsus for the small segment that bears the claws. In *Tomocerus* the tibiotarsus, functionally a single segment, is morphologically at least two segments, as shown by the presence of a suture just above the tenent hair. Occasionally a second suture occurs as an abnormality, dividing the tibiotarsus into three segments (fig. 3), which are probably a

tibia and two tarsal segments—a primitive condition normal in *Pauropus* and *Polydesmus*. In *Tomocerus*, as in other Collembola,

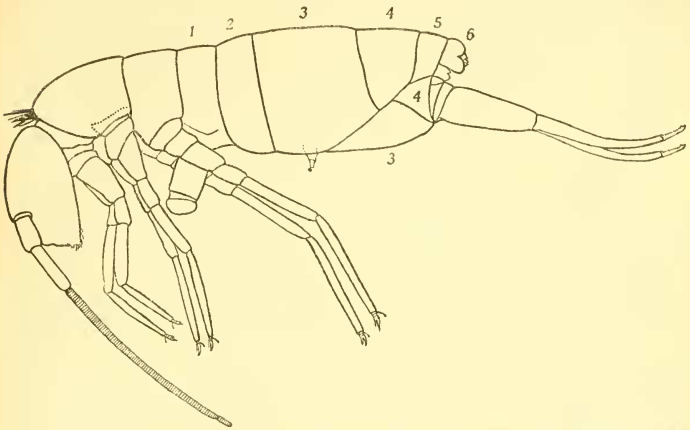

FIG. 2.—TOMOCERUS FLAVESCENS, VAR. AMERICANUS. THE ABDOMINAL SEGMENTS ARE NUMBERED. × 20.

two pre-coxal segments are present (fig. 2). These Willem ('00, p. 93) regards as equivalent to the two pre-coxal segments of the cockroach, that occur in other Orthoptera under various modifications, as described by Miall and Denny.

FIG. 3.—TOMOCERUS FLAVESCENS, VAR. AMERICANUS. TIBIOTARSUS SHOWING AN ABNORMAL THIRD SEGMENT. × 57.

The structure of the claws of *Tomocerus* has been described minutely by Absolon ('03). Some disagreement has existed in regard to the precise structure of the teeth of the unguis, which are of considerable phylogenetic importance. In a lateral view of the unguis a single series of teeth is seen, as in plate 40, figure 3. Willem ('00, p. 45) maintained that these minute teeth are not single, but paired, the two teeth of each pair being side by side, and one hiding the other in a lateral aspect of the claw. Börner ('01, p. 39) described the unguis as being triangular in transverse section, with a simple, or

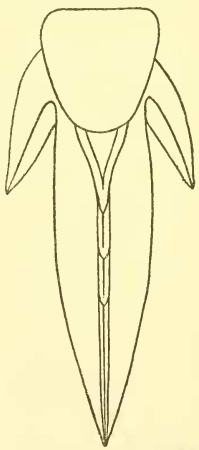

FIG. 4.—TOMOCERUS FLAVESCENS, VAR. AMERICANUS. CONCAVE ASPECT OF UNGUIS TO SHOW THE FORM OF THE TEETH. × 644.

unsplit, inner edge, on which the teeth are situated; these teeth being simple, not doubled. Absolon ('03, p. 103) described the inner edge ("Innenkante") as being formed by the union of the edges of two lamellæ, with a series of simple teeth on one of these lamellæ.

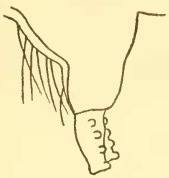

FIG. 5.—TOMOCERUS FLAVESCENS, VAR. AMERICANUS. LEFT SIDE OF TENACULUM. × 238.

Wahlgren ('06*a*, p. 64) arrived independently at the same conclusion as Absolon. I find that the inner border is formed by the united edges of two lamellæ, that the teeth are simple, and that each tooth arises from both lamellæ, as in figure 4—not from one of them. My figure for *T. flavescens* var. *americanus* agrees essentially with that of Börner ('01, p. 39) for *T. plumbeus* (Linnæus) Tullberg, the species used by all these European investigators; and in examples of the latter species, received from Doctor Schäffer, I have seen the teeth as described by Börner. Wahlgren's figure ('06*a*, p. 64) is correct for an oblique view of the claw, but is misleading as to the exact relation of the teeth to the pair of lamellæ. In order to see this relation, the claw must be turned until it presents a symmetrical view, as in figure 4.

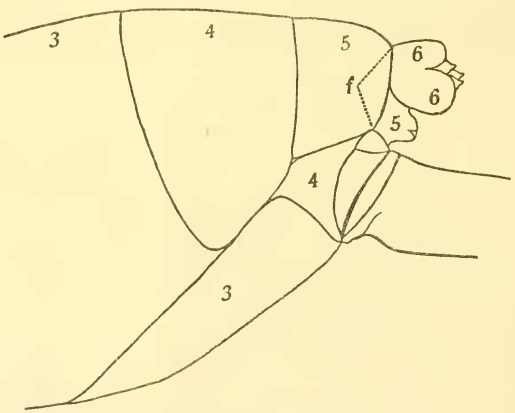

FIG. 6.—TOMOCERUS FLAVESCENS, VAR. AMERICANUS. POSTERIOR SEGMENTS OF ABDOMEN, NUMBERED TO SHOW RELATIVE POSITIONS OF TERGA AND STERNA. *f*, FOLD. × 39.

The tenaculum (fig. 5) of the third abdominal segment does not vary greatly in the genus *Tomocerus*. The base of the tenaculum bears anterior setæ, which differ somewhat in number and position in different species without, however, having any specific value of practical importance.

The furcula is an appendage of the fourth abdominal segment in all Collembola. This relation, evident in the more generalized genera, as *Achorutes*, is not obvious in such forms as *Tomocerus* without the aid derived from a study of certain other genera, particularly *Isotoma*. Indeed, it has been said frequently that the furcula in *Tomocerus* is appended to the fifth abdominal segment. The correct view is that maintained by Willem ('00, pp. 40, 45), to whose evidence I can add a little, as follows:

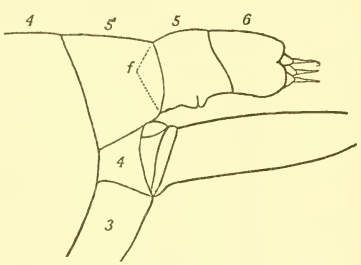

FIG. 7.—TOMOCERUS FLAVESCENS, VAR. AMERICANUS. POSTERIOR SEGMENTS OF ABDOMEN OF MALE, SHOWING PROTRUDED GENITAL SEGMENT. *f*, FOLD. × 30.

In a specimen treated with hot potassium hydroxide a suture becomes evident that separates the sternum of the fourth abdominal segment from the tergum of the fifth, as in figure 6.

Before such treatment the suture is indistinguishable, and the furcula appears to be attached to the fifth abdominal segment.

Willem ('00, p. 44) notes that the genital segment (fifth abdominal) is more elongate in the male than in the female. This elongate condition is shown in figure 7, in which the genital segment is extended for its entire length. When not extended the posterior part of the segment is telescoped into the anterior part, giving the appearance shown in figure 6, in which *f* represents the external line of folding, which might easily be mistaken for a suture. In the female the genital segment is telescoped but slightly.

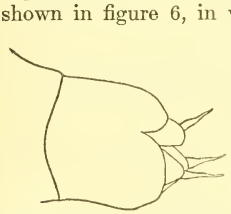

FIG. 8.—TOMOCERUS FLAVESCENS, VAR. AMERICANUS. ANAL SEGMENT OF MALE, SHOWING CERCI. × 102.

Willem called attention also to the presence of three "cerci" on the anal segment, and stated that these are shorter in the male than in the female. The so-called cerci, one dorsal and two ventral, are shown in figures 7 and 8.

Returning to the furcula—each dens is divided by two transverse sutures into three regions (fig. 9). In brittle alcoholic specimens the dens frequently breaks at one or the other of these sutures. The dental spines are limited to the middle and the proximal region or to the middle region. These spines, as regards number, relative size, form, and arrangement, furnish good specific characters. The spines increase in number with the age of the individual and vary a little in number in individuals of the same age. It follows that one should

hesitate to describe a species of *Tomocerus* as new until he has ascertained, at least approximately, the range of variation in these dental spines; and that of the claws and body color as well, it may be added.

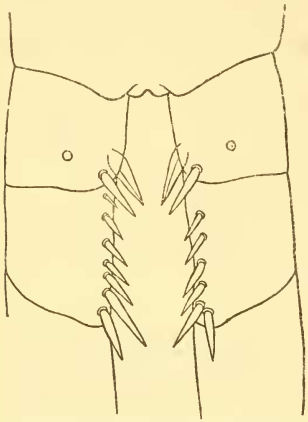

FIG. 9.—TOMOCERUS FLAVESCENS, VAR. SEPARATUS. BASES OF DENTES TO SHOW SEGMENTATION AND SPINES. × 124.

For describing the dental spines Ågren ('03, p. 144) used a formula which has been generally adopted. Such a formula for plate 40, figure 2, would be $\frac{1}{7, 2}$. Here the horizontal line represents the suture between the proximal and middle series of spines, and the fat-faced type indicates the larger size of certain spines. In this paper I have changed the formula a little by running it on a single line, using an oblique line to indicate the suture. Thus the preceding formula becomes **1/7, 2**.

The form of the mucrones is distinctive of *Tomocerus* (and *Tritomurus*) if we leave out of consideration two apparently aberrant European species, namely, *doderii* Parona and *niveus* Joseph. Each mucro (fig. 10) bears dorsally (the furcula being extended behind the body) two large proximal teeth, an apical tooth or hook, and a large anteapical tooth; and between the basal and apical teeth there is, in almost all species of the genus, a series of small, equal, "intermediate teeth," which vary slightly in number in individuals of the same size.

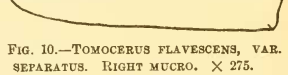

FIG. 10.—TOMOCERUS FLAVESCENS, VAR. SEPARATUS. RIGHT MUCRO. × 275.

Key to Species of Tomocerus.

Intermediate dental spines subequal or gradually increasing in size distally; two large distal spines (plate 40, figs. 2, 4, 6)..... *flavescens*, *p.* 457.

Intermediate dental spines unequal, with a large spine near the middle of the series; one large distal spine (plate 40, fig. 8; plate 41, figs. 10, 13, 14).

Teeth of unguis 4 to 7:

Dental spines simple..... *vulgaris*, *p.* 463.

Dental spines tridentate..... *minor*, *p.* 466.

Teeth of unguis 2..... *bidentatus*, *p.* 463.

TOMOCERUS FLAVESCENS Tullberg.

Plate 40, figs. 1, 2.

Macrotoma flavescens TULLBERG, 1871; 1872.—REUTER, 1876.—UZEL, 1890.
Tomocerus flavescens SCHÖTT, 1894.—DALLA TORRE, 1895.—SCHÄFFER, 1896.—POPPE and SCHÄFFER, 1897.—LIE-PETTERSEN, 1897; 1898.—SCHERBAKOV, 1898*a*, 1898*b*.—CARL, 1899; 1901.—SKORIKOW, 1900.—KRAUSBAUER, 1901.
Tomocerus niger REUTER, 1895.—CARPENTER and EVANS, 1899.—SCHÄFFER, 1900.—BÖRNER, 1901.—FOLSOM, 1902.—AXELSON, 1904.—BANTA, 1907.
Tomocerus plumbeus PACKARD (part), 1873.—ÅGREN, 1903.—(Axelson) LINNANIEMI, 1905, 1906, 1907.—WAHLGREN, 1906.
Pogonognathus plumbeus BÖRNER, 1909.—(Axelson) LINNANIEMI, 1912.

Description.—The typical *T. flavescens* as known in Europe has the following distinguishing characters, as appears from the published descriptions and figures and from the specimens that I have received:

Body color yellow; either pure yellow or with a varying amount of purplish or grayish pigmentation, especially on the anterior border of the mesonotum, on the coxæ, tibiæ, distal portions of the femora, and the first two antennal segments; the last two being purplish. Antennæ shorter than the body. Unguis (pl. 40, fig. 1) usually bidentate, occasionally tridentate. Unguiculus lanceolate, with one tooth or with none. Dental spines (pl. 40, fig. 2) 6 to 8; large spines three; one proximal and two distal; the intermediate spines becoming successively smaller toward the base of the dens. Near each large proximal spine is a transparent lanceolate lamella. Length 5 mm., occasionally 6 mm.

Variation.—There is great variation in the body color. Tullberg's original description reads, "ground-color yellowish gray or pure yellow," and Brook refers to the color variation as follows: "The majority have had yellow as the basis of the ground-color, sometimes with brown patches and sometimes with the yellow fading away into a leaden color almost like that of the scales."

Tullberg gave the first recognizable description of this species. His description, giving the teeth of the unguis as two and the dental spines as seven or eight, has been supplemented by Ågren ('03), who mentions the occurrence of three teeth on the unguis and gives as the formula for the dental spines **1**–**3**/3–5, **2**. In eight European specimens sent to me by Doctor Schäffer the teeth of the unguis number either two or three, and the dental formula is **1**/4–5, **2**.

Some of my specimens from various parts of the United States agree exactly with European descriptions and specimens of the species. In this country, however, three teeth on the unguis are the rule in large specimens, small individuals having usually two, and in large specimens the number of dental spines ranges from 9 to 12, inclusive; thus specimens 4.5 to 5 mm. in length have the formula **1**/8, **2** or **1**/9, **2**.

Some of our American specimens have the clear yellow body color of the typical European *flavescens*, but as a rule the color is ocher yellow or buff or cream yellow. Before the scales are removed the insect is lead-colored. As a rule, the antennæ are shorter than the body. I have, however, from Georgia, a single specimen of unusual size (length 6 mm.), in which the antennæ are longer than the body, in the ratio of 8:7, and curl at the ends.

The number of intermediate teeth on the mucro ranges from five to twelve in specimens 2.5 mm. or more in length, with an average of seven or eight. The unguiculus is usually one-toothed, and on the largest specimens a small second tooth may be present.

The prevalent American variety, with tridentate ungues (pl. 40, fig. 1), is the form that I have been referring to, in correspondence, under the name of *separatus*.

From the original descriptions one might infer that *T. flavescens* Tullberg, *T. americanus* Schött, and *T. arcticus* Schött were three different species. Such is not the case, however, as I have already pointed out. (Folsom '02, p. 97–102.) In Alaska the three forms intergrade in one and the same locality; though in most other parts of the United States the three are fairly distinct. *Flavescens* is, for purposes of nomenclature, the typical form, with *separatus*, *americanus*, and *arcticus* as its varieties, and these forms may ordinarily be distinguished as follows:

Key to forms of Tomocerus flavescens Tullberg.

One or two large dental spines at the proximal end of the series.
  One large proximal spine:
    Teeth of unguis 2 ..... *T. flavescens*, typical form.
    Teeth of unguis 3 ..... *T. flavescens*, var. *separatus*, new variety.
  Two large proximal spines; teeth of unguis 3 or 4. *T. flavescens*, var. *americanus* Schött.
No large proximal dental spines; teeth of unguis 4, rarely 5, var. *arcticus* Schött.

This table refers to large specimens (2.5 mm. or more in length); in small specimens there are fewer teeth on the large claws and fewer spines on the dentes.

Synonymy.—Tullberg described *flavescens* in 1871 and 1872, and all the European authorities know what form he meant. His description, being the first adequate diagnosis of the species, should be accepted in the interests of stability. Several writers, however, have tried to supplant *flavescens* with previous names, based on insufficient descriptions, to the confusion of the nomenclature. The name used most often to supersede *flavescens* has been *niger* of Bourlet ('39, p. 390), whose description of *Macrotoma nigra* is as follows:

Même longueur que la précédente pour le corps et les antennes; corps couvert d'écailles noires, offrant à la vue simple un léger reflet argenté. Corps dépouillé de ses écailles, présentant une couleur d'un jaune de cire. Bord antérieur du thorax

garni d'une frange de poils noirs et courts; antennes grises, ou d'un gris fauve; pattes d'un brun verdâtre, tarses bruns, ventre jaunâtre. Cette espèce, ainsi que la précédente, se trouve sous les pierres et le vieux bois.

This description is so broad as to have scarcely any specific value. The expression "wax-yellow" has, however, been seized upon by "priority-hunters" as an excuse to drop the name *flavescens* in favor of *niger*.

Ågren ('03, p. 145) believed that the name *flavescens* should be retained, but nevertheless proposed a still earlier name, *plumbea* Templeton, since Templeton ('35, p. 93) described *Podura plumbea* as having a golden yellow body color. Now at least four other writers have followed Ågren and adopted the name *plumbea*, though Templeton's description is so vague that previous authorities had agreed in rejecting it.

As a matter of fact, *flavescens* is not the only European species of *Tomocerus* with a clear yellow body color. *T. vulgaris* is often bright yellow, so that Schött ('94, p. 41) thought it most probable that *vulgaris* was the species named *niger* by Bourlet. *T. tridentiferus* Tullberg is also sometimes yellow, as Carpenter and Evans ('99, p. 237) have noted; and *T. sibiricus* Axelson is characteristically bright yellow.

In fact, yellow is the basis of the body color in many species of *Tomocerus*, and the body color is so variable as to be of little specific importance, as Brook ('83, p. 23) showed long ago.

The only justifiable course is to retain the name *flavescens* Tullberg.

The specimens of *Tomocerus* that I determined for Banta ('07, p. 55) are *flavescens* Tullberg, var. *americanus* and var. *separatus*.

The specimens that Packard ('73, p. 38) referred to *T. plumbeus* Linnæus belong to two species: *vulgaris* Tullberg and *flavescens* Tullberg. These specimens are in the Museum of Comparative Zoölogy, Cambridge, Massachusetts, where I studied them. Of those labeled "Brunswick, Me., Sept. 10, A. S. P.," four are *flavescens;* "Salem, Mass., A. S. P.," six *flavescens;* "Knoxville, Tenn., Dr. J. Curtis," 136 *flavescens*. All these specimens of Packard's are of the common tridentate form that I call *separatus* to distinguish it from the typical bidentate form of Tullberg's description.

Distribution.—The typical bidentate form of *flavescens*, as described by Tullberg, is rare but widely distributed in this country, so far as I can infer from the material I have studied. The following are the only records that I have of its occurrence:

Illinois.—Urbana, March 19.

Tennessee.—Knoxville, April 5, H. E. Summers.

California.—V. L. Kellogg (Stanford University, J. W. F.).

Washington.—V. L. Kellogg, L. Bremner (Stanford University, J. W. F.).

In most parts of Europe *T. flavescens* is a common species.

TOMOCERUS FLAVESCENS Tullberg, var. SEPARATUS, new variety.

Plate 40, figs. 1, 2.

This tridentate variety, already referred to, is well established in this country, and to distinguish it from the typical bidentate form which is common in Europe but rare here, I have been using the varietal name *separatus*.

Maine.—Brunswick, September 10, A. S. Packard, jr. (M. C. Z.). Orono, October, F. L. Harvey.

New Hampshire.—Jaffrey, September, S. Henshaw. Franconia, Mrs. A. T. Slosson. Walpole, July 14.

Massachusetts.—Salem, September, December, A. S. Packard, jr. (M. C. Z.). Arlington, April 4, 17, 23, May 14, August 6, 15, 16, September 19, 21, 30, October 1, 13, 14, 17, November 6, December 10. Belmont, April 19. Waltham, July 29. Wellesley, February 25, A. P. Morse. Weston, July 16.

New York.—Ithaca, July 1, September 24, A. D. MacGillivray. Long Island, N. Banks.

Pennsylvania.—Hazleton, G. W. Dietz. Harrisburg, February 24, October 4, November 6, 14, 24, December 14, H. A. Surface. Lewisburg, October 25, H. A. Surface. Rockville, April 7, H. A. Surface. Tyrone, April 3, H. A. Surface. Highspire, January 20, April, September 22, H. A. Surface. Eberly's Mill, July 28, H. A. Surface. Kennett Square, April 16, H. A. Surface. Hummelstown (limestone cave), November, H. A. Surface.

District of Columbia.—Washington, February 2, N. Banks.

Georgia.—Burton, May 20, J. C. Bradley. St. Simon Island, May, J. C. Bradley. Rabun County, May 24, J. C. Bradley.

Tennessee.—Knoxville, Dr. J. Curtis (M. C. Z.); April 5, March 15, H. E. Summers. Cloud Ford, August, C. C. Adams.

Ohio.—Salem, March 21, A. D. MacGillivray. Salineville, February 4, December 24, A. D. MacGillivray.

Indiana.—Richland (Mayfield's cave), May 6, 8, June 4, October 29, December, A. M. Banta (A. M. B., J. W. F.).

Illinois.—Urbana, April 9, October 19, 26.

Missouri.—Columbia, October 19, G. I. Reeves. St. Louis, January 27, H. Schwarz.

Michigan.—Washtenaw County, November 3, J. Dawson (Univ. Mich.).

Cotypes.—Cat. No. 16261, U.S.N.M.

TOMOCERUS FLAVESCENS Tullberg, var. AMERICANUS Schött.

Plate 40, figs. 3, 4.

Tomocerus americanus Schött, 1896.
Tomocerus plumbeus Packard (part), 1873.
Tomocerus niger, var. *americanus* Folsom, 1902.
Tomocerus arcticus Guthrie, 1903.

Description.—Ungues tridentate or quadridentate (pl. 40, fig. 3). Unguiculus unidentate. Dental spines nine to eleven, rarely twelve, the two proximal and the two distal considerably larger than the rest (pl. 40, fig. 4). Dental formula typically **2**/5–7, **2**; rarely **2**/8, **2**. Length 4 mm.

Variation.—The body color, clear yellow in Alaskan specimens, is highly variable in specimens from other parts of the United States. Thus it may be cream yellow, straw yellow, bright ferruginous or grayish; the grayish specimens frequently having elongate rounded oblique whitish spots on the sides of the thorax and abdomen. In Illinois I have collected at one time specimens illustrating all these color variations from a single square foot of soil. A variable amount of dark pigment occurs on the anterior border of the mesonotum, on the coxæ, tibiæ, and distal ends of the femora, and on the abdominal segments and the manubrium.

The teeth of the ungues are commonly 4, 4, 4; 3, 3, 3; or 4, 3, 3. The tooth of the unguiculus is occasionally absent. The intermediate teeth of the mucrones vary from six to ten in specimens three to four millimeters in length, with an average of eight or nine.

Tomocerus americanus can not be regarded as a distinct species, since it intergrades with typical *flavescens* in all the characters that are of specific importance, as I showed in my paper on Alaskan Apterygota ('02, p. 99). Such intergradations as these occur:

Teeth of unguis.	Dental formula.	Locality.
2, 2, 2	**2**/4, **2**	Alaska, Tennessee,
2, 2, 2	**2**/5, **2**	Alaska, Illinois.
4, 3, 3	**1**/5, **2**	Indiana, Missouri.

Frequently the same individual has spines of *flavescens* on one dens and those of *americanus* on the other.

One of my specimens from Indiana is especially interesting as a transitional form. The spines of the right dens are those of typical *flavescens*. Those of the left dens are *flavescens* varying into *americanus;* for the second large basal spine is represented by a greatly thickened hair; while on the right dens in the corresponding place there is a simple hair.

Synonymy.—Of the specimens referred to *T. plumbeus* Linnæus by Packard ('73, p. 38), those from Texas are *americanus*. The specimens, three in number, labeled "Waco, Tex., Belfrage," were studied by me in the Museum of Comparative Zoölogy, Cambridge, Massachusetts, in 1897–98. They had quadridentate ungues. Only one specimen, however, retained enough of the furcula to show the spines; these were **2**/5, **1** on the right side and **2**/3, **2** on the left.

The form regarded as *T. arcticus* by Guthrie ('03, p. 79) is *americanus*, as is evident from his description and figures as well as from seventeen of his original specimens that I have examined.

Distribution.—The variety *americanus* is widespread in the United States.

New Hampshire.—Walpole, July 14. Mount Washington, Mrs. A. T Slosson.

Massachusetts.—Arlington, April 23, September 12, October 14, December 10. Norwood, August 26. Weston, June 12.

New York.—Ithaca, July 21, September 24, A. D. MacGillivray.

New Jersey.—Jamesburg, July 4, N. Banks.

Virginia.—Fredericksburg, February 18, W. D. Richardson. New Church, January 4, W. J. Phillips.

Ohio.—Oxford, November 4, S. R. Williams. Yellow Springs, April 3, August 28, 29. Salem, April 3, A. D. MacGillivray. Salineville, February 4, December 25, 29, A. D. MacGillivray.

Indiana.—Indianapolis, February 2, J. D. Hood. Richland (Mayfield's cave), May 8, A. M. Banta (A. M. B., J. W. F.).

Illinois.—Somer, April 6, August 12, October 26, 29, November 2, 6. Urbana, March 19, October 4, 19, 25. Mount Carmel, November 9.

Tennessee.—Knoxville, April 4, 5, H. E. Summers.

Missouri.—Columbia, February, C. R. Crosby.

Michigan.—Isle Royale, July 24, H. A. Gleason (Univ. Mich., J. W. F.).

Minnesota.—May 25, July 30, August 5, J. E. Guthrie (Univ. Minn.).

Mississippi.—Agricultural College, H. E. Weed.

Texas.—Waco, G. W. Belfrage (M. C. Z.).

New Mexico.—Beulah, May 3, T. D. A. Cockerell.

California.—San Francisco, G. Eisen (Cal. Acad. Sci.). Palo Alto, V. L. Kellogg (Stanford Univ., J. W. F.).

Oregon.—Siskiyou, September 6, A. P. Morse. Benton County, August 21, H. E. Ewing. Mount Chintimini, 5,000 feet, H. E. Ewing.

Washington.—L. Bremner. Olympia, T. Kincaid.

Alaska.—Muir Glacier, June 12 (U.S.N.M.). Cook Inlet (U.S.N.M.) Yakutat Bay, June (U.S.N.M., J. W. F.).

TOMOCERUS FLAVESCENS Tullberg, var. ARCTICUS Schött.

Plate 40, figs. 5, 6.

Tomocerus arcticus Schött, 1894.—Dalla Torre, 1895.—Schäffer, 1900*b*.—Skorikow, 1900.

Tomocerus niger, var. *arcticus* Folsom, 1902.

Description.—Body color citron yellow. Antennæ two-thirds the length of the body; first two segments yellow, second often purplish distally; last two pale purple. Legs yellow throughout. or with

purplish coxæ and tibiæ. Ungues (pl. 40, fig. 5) quadridentate, occasionally five-toothed; unguiculi unidentate, the tooth sometimes obscure or absent, however. Dental spines (pl. 40, fig. 6) normally six or seven on each side, rarely eight, becoming successively larger distally; formula **0**/4–6, **2**; two large ovate-lanceolate acuminate transparent lamellæ occur near the manubrium, as usual in *flavescens*. Maximum length, 4 mm.

Variation.—In a single lot of fifty-five specimens from the Muir Glacier, Alaska, I found some individuals with one large proximal spine on each dens and with ungues either quadridentate or tridentate. These variations into typical *flavescens* I have discussed in a previous paper ('02, p. 101).

Distribution.—Hitherto this variety has been known only from the far north (the "*arcticus*" of Guthrie ['03, p. 79] being *americanus*). It was discovered by the *Vega* Expedition in 1878–9 in eastern Siberia, and found by the Harriman Expedition in 1899 in Alaska. The Harriman specimens, now in the U. S. National Museum, were taken at Popof Island, Cook Inlet, Sitka, Yakutat Bay, and Muir Glacier. The following records extend the known range southward.

Washington.—Olympia, T. Kincaid.

Oregon.—Corvallis, December 24, H. E. Ewing.

TOMOCERUS BIDENTATUS, new species.

Plate 40, figs. 7, 8.

Body color yellow, mottled throughout with dark pigment. Eyes six on each side. Antennæ shorter than the body; purple throughout, or with first two segments yellow. Unguis (pl. 40, fig. 7) stout, usually bidentate, occasionally tridentate; unguiculus broadly lanceolate, untoothed. Dental spines (pl. 40, fig. 8) thirteen to seventeen; formula 3–4, **1**/4–6, **1**, 3–4, **1**; basal lamellæ present, as in *flavescens*. Mucrones with four to seven intermediate teeth. Length, 2.2 mm.

Rarely the distal tooth of the unguis is absent.

The dental spines suggest those of *T. vulgaris*, but the claws of the two species are quite different, as appears from a comparison of figures 7 and 9 of plates 40 and 41, respectively.

Twenty-eight cotypes. Yellow Springs, Ohio, August 28. Knoxville, Tennessee, April 5, H. E. Summers. New Church, Virginia. January 4, W. J. Phillips.

Cotypes.—Cat. No. 16262, U.S.N.M.

TOMOCERUS VULGARIS Tullberg.

Plate 41, figs. 9–11.

Macrotoma vulgaris TULLBERG, 1871; 1872.—UZEL, 1890.
Tomocerus plumbeus PACKARD (part), 1873.

Tomocerus vulgaris TULLBERG, 1876.—REUTER, 1891; 1895.—BROOK, 1883.—DALLA TORRE, 1888.—SCHÖTT, 1894.—SCHÄFFER, 1896; 1900*a*; 1900*b*.—POPPE and SCHÄFFER, 1897.—SCHERBAKOV, 1898.—CARPENTER and EVANS, 1899.—CARL, 1899.—SKORIKOW, 1900.—ABSOLON, 1903.—BÖRNER, 1901.—KRAUSBAUER, 1901.—ÅGREN, 1903.—(Axelson) LINNANIEMI, 1905, 1907, 1912.—WAHLGREN, 1906*b*.

Podura vulgaris VOIGTS, 1902.

Tomocerus niger GUTHRIE, 1903.

Description.—General color purplish black; when denuded of scales, clear yellow, dull yellow, yellowish white, dirty white, or gray. Antennæ two-thirds as long as the head and body in large specimens; third and fourth segments, and often the second segment, purplish. Tibiæ often dusky. Unguis slender (pl. 41, fig. 9), four to six toothed; unguiculus lanceolate, often minutely unidentate. Tenaculum with twelve or thirteen anterior setæ in large specimens. Dental spines simple, usually 13 to 15, less often 12 or 16, and rarely 17 or 18, on each side; formula usually 4–6, 1/2–5, 1, 2, 1; extreme formula 4–7, 1/2–5, 1, 1–3, 1. The large dental spines are constant in number and position, and the first and third of these are out of line with the rest of the series, being more lateral in position (pl. 41, fig. 10). Mucrones with five to seven intermediate teeth, rarely more (pl. 41, fig. 11). On the dorsum of the head are several stiff, finely feathered setæ. Mesonotal collar of dense setæ. Maximum length, 4 mm.

Variation.—The body-color is quite variable, as already noted. Frequently the anterior border of the mesonotum is pigmented, while the rest of the body is unicolorous; sometimes the meso- and metanotum and the bases of the legs are mottled with pigment; or the entire body may be mottled. Individuals of different sizes show marked structural differences. With age, the subsegments of the third antennal segment increase in number and become shorter, and this segment increases in relative length, as do also the third abdominal segment and the dentes; furthermore, the teeth of ungues and mucrones and the spines of the dentes increase in number. Some of these changes in ratio and number are expressed in the following table, adapted from one by Schäffer (1900, p. 275). The measurements are from successively larger insects, beginning with very small specimens (No. 1):

Size.	Ant. 4: Ant. 3.	Ant. 4: Dens.	Mucro: Dens.	Abd. 4: Abd. 3.	Teeth of Unguis.	Middle teeth of Mucro.
1	1:1	1:1	1:2.5	1:1	1	1
2	1:1	1:1	1:4	1:1	Obscurely 4–6.	2
3	1:1.3	1:1	1:4	1:1.3		3
4	1:1.5	1:1	1:4	1:1.3	Clearly 4–6.	3
5	1:1.75	1:1.5	1:5	1:1.5		7
6	1:2.9	1:1.8	1:5.9	1:1.5		8

As Schäffer remarks, the postembryonal changes are so great that one knowing only the smallest and the largest individuals might easily mistake them for two distinct species.

In the largest specimens the unguis sometimes shows a trace of a seventh tooth at the distal end of the series. The tooth of the unguiculus may or may not be present, but usually occurs on large, well-preserved specimens. The total number of dental spines increases with age and varies slightly in individuals of the same size. Ågren gives the formula for European specimens as 4–6, **1**/3, **1**, 2, **1**. This would apply also to most American specimens, though a more representative formula is 4–6, **1**/2–5, **1**, 2, **1**. Rarely the formulæ 7, **1**/5, **1**, 2, **1** and 4, **1**/2, **1**, 3, **1** occur.

Linnaniemi ('12, p. 179) gives as the extreme formula for the dental spines 5–7, **1**/**1–2**, 3, **1–2**, 1–2, **1**. I have never seen, however, *large* spines at the base of the second series. Regarding the spines as forming two series, separated by the transverse suture, new spines appear at the base of each series, and these spines are small. In the number of spines the dentes of the two sides seldom differ by more than one.

The number of intermediate teeth on each mucro is rarely eight to eleven.

Reuter ('91, p. 228) gave the name of *sibiricus* to a variety of *vulgaris*, characterized by its yellow body color and twelve dental spines—five proximal and seven distal. Linnaniemi ('07, '09, '12) regards *sibiricus* as a distinct species, and has described it fully ('12, p. 180) as *sibiricus* (Reuter) Axelson. His material is certainly not *vulgaris*, since the dental spines have the formula 1–3, **2**/3–5, **2–3**, and their maximum number is only thirteen, even in specimens 4 mm. in length.

There is, however, a clear yellow variety of *vulgaris*, of which I have specimens from Germany (from Schäffer) and from Maine, Massachusetts, and Colorado, along with gradations between the yellow variety and a heavily pigmented form.

Synonymy.—*T. vulgaris* is a common species in Europe, where there has been no question as to the validity of the name *vulgaris*, Tullberg's description and figures being sufficient to define the species.

My American specimens agree with the European examples that I have received from Schäffer.

Some of the specimens referred to *T. plumbeus* Linnæus by Packard ('73, p. 38) are *T. vulgaris*, as I found by an examination of his specimens in the Museum of Comparative Zoölogy at Cambridge. Thus one of the five specimens labeled "Brunswick, Me., Sept. 10, A. S. P." is *vulgaris*, and six of the twelve labeled "Salem, Mass., A. S. P." are *vulgaris*.

Guthrie ('03, p. 80) found *vulgaris* in Minnesota. His figures leave no doubt as to what species he had in hand, and his specimens, which I received for study, are *vulgaris*. Guthrie, however, put *vulgaris* as a synonym of *niger* Bourl.

Distribution.—*T. vulgaris* is common under loose bark, under logs or boards on the ground, under stones or dead leaves, and among decaying fruits or vegetables; it occurs in greenhouses also.

Maine.—Brunswick, September 10, A. S. Packard, jr. (M. C. Z.). Orono, April 22, October, F. L. Harvey.

New Hampshire.—Franconia, Mrs. A. T. Slosson.

Massachusetts.—Salem, A. S. Packard, jr. (M. C. Z.). Cambridge or Arlington, January 16, February 1, 25, 26, 28, March 1, 10, 11, 26, 27, 28, April 8, 9, 11, 12, 13, 17, 22, 23, 30, May 7, 20, 23, June 1, 2, 6, 8, 10, July 10, 12, 16, 22, 30, August 20, 23, September 11, 15, 17, 21, 22, 25, October 2, 13, 19, 26, November 16, 27, December 3, 7, 10. Wellesley, March 11, A. P. Morse.

New York.—Ithaca, April 19, September 24, A D. MacGillivray.

Pennsylvania.—Hazleton, May 29, June, W. G. Dietz.

Illinois.—Champaign, August 13. Urbana, March 27, April 7, 9, 11, 21, October 21.

Colorado.—Fort Collins, February 5, C. F. Baker.

Minnesota.—Minneapolis, January 2, May 19, J. E. Guthrie (Univ. Minn.).

Washington.—L. Bremner.

Canada.—Ontario Peninsula, September 25, October 25, G. S. Miller, jr.

TOMOCERUS MINOR Lubbock.

Plate 41, figs. 12–14.

Macrotoma minor Lubbock, 1862.

Macrotoma tridentifera Tullberg, 1872.—Uzel, 1890.—Reuter, 1890.

Tomocerus plumbeus Lubbock, 1873.

Tomocerus tridentiferus Brook, 1883.—Schött, 1894.—Reuter, 1895.—Carpenter, 1895; 1904; 1907.—Schäffer, 1896.—Lie-Pettersen, 1897; 1898.—Poppe and Schäffer, 1897.—Carl, 1899; 1901.—Carpenter and Evans, 1899.—Skorikow, 1900.—Willem, 1900; 1902.—Absolon, 1901.—Krausbauer, 1901.

Tomocerus norvegicus Lie-Pettersen, 1897.

Tomocerus minor Schäffer, 1900*a*.—Börner, 1901.—Schött, 1902.—Ågren, 1903.—(Axelson) Linnaniemi, 1906; 1907; 1911; 1912.—Wahlgren, 1906.

Description.—The body, with scales, is lead colored, becoming purplish in large individuals. Denuded of scales, the body varies from yellow to blackish; commonly the yellow ground color is thickly powdered with blackish dorsally and laterally, and the sides of the thorax and of the first two abdominal segments have conspicuous yellow oblique spots. Occasionally the body color is reddish. Antennæ shorter than the body; basal segment usually yel-

lowish; the other segments purplish. Unguis (pl. 41, fig. 12) long, slender, slightly curved, five to seven toothed; unguiculus unidentate. Dental spines (pl. 41, fig. 13) tridentate, commonly nine to fifteen in large specimens, rarely as many as twenty; formula usually 4–6/2–5, **1**, 1–2, **1**. Intermediate teeth of mucrones five to eight, as a rule, sometimes nine or ten. Length, 4 mm.

Variation.—North American specimens agree with the six European examples that I received from Doctor Schäffer. The unguis is usually six-toothed, but may be five-toothed through the absence of the distal tooth; and some of the largest specimens may have seven teeth, owing to the addition of a small tooth at the distal end of the series. The number of dental spines in one large specimen that I have from the State of Washington is as many as twenty, with the formula 8/8, **1**, 2, **1** (pl. 41, fig. 14), and the spines fall into two longitudinal series—a variation mentioned by Linnaniemi ('12). Rarely a spine bears a small fourth tooth.

Distribution.—*T. minor* occurs in almost all parts of Europe. My North American specimens are from few but widely separated localities.

Massachusetts.—Cambridge, January 26, February 2, 9, 18, 23, 25, March 1, 8.

Washington.—L. Bremner.

Canada.—Toronto, Ontario, June 26, R. J. Crew.

All the Massachusetts specimens were collected by me in a greenhouse, and I was unable to find the species out of doors, even in the immediate vicinity of the greenhouse mentioned. In regard to the habitat of the specimens from the State of Washington and from Canada, I have no data.

CAVERNICOLOUS SPECIES OF TOMOCERUS.

Packard ('77, p. 159) described as follows a white variety of *Tomocerus* from a cave in Utah:

Tomocerus plumbea (Linn.) var. *alba.*—Several specimens of a pale variety of this species of "spring-tail" occurred, some of which were pure white, thoroughly bleached out, while others were more or less dusky. Several of the larger specimens were pale, with traces of dark markings on the body; the antennæ, legs, and "spring" were white, much paler than the body. In such examples the antennæ are whitish, with the two basal joints tinged with brown, the flagellum white, with a slight purplish tinge. Legs and spring almost pure white. Eyes black and well developed. Specimens one-half or two-thirds grown are pure white, except the small, black eyes, which are connected by a double black line; while other specimens, fully grown, are perfectly white.

Similar individuals occurred in the Carter Caves of eastern Kentucky, and still others occurred which were much darker than the Utah ones, forming a series connecting the extreme white variety, *alba*, with the ordinary plumbeous form, which latter is found in the United States east of the Mississippi, Greenland, and Europe.

The occurrence of the white variety in a cave indicates that the ordinary form is probably to be met with west of the Rocky Mountain range.

Had I not had a series from the Carter Caves connecting the white variety with the ordinary out-of-door plumbeous form, I might have been inclined to regard it as a new and undescribed species, although it represents no structural differences in the form or length of the appendages from the normal form. But the series affords a capital example of the successive steps in the formation of a new form, whether we call it a new variety or species, while the causes of the changes are sufficiently apparent. Examples such as these and others I have before me to be hereafter described amount almost to demonstrative evidence of the truth of the doctrine of the transformation of species.

Some years later Packard ('88, p. 65) described from caves in Kentucky and Virginia a form that he took to be the same white variety, but for which he used, perhaps inadvertently, a second name—*pallidus*. His account follows:

Tomocerus plumbeus Templeton, var. *pallidus*.—One specimen from Zwingle's Cave was but slightly changed, being almost wholly plumbeous; it occurred one-quarter of a mile from daylight (Sanborn).

In a number of other specimens from Zwingle's Cave and others of the Carter Caves the body is white, as well as the spring and the legs, but the tarsi retain a slight plumbeous tinge. The antennæ are partly pale, the two basal joints being bathed with leaden gray. Ten examples collected by us had distinct black eyes, but minute and angular in outline, having suffered a considerable reduction in size. Specimens collected by us from the ice-house cave were white, with dusky antennæ and black eyes, and were like those just described.

Specimens from X Cave were all bleached, like those from the other Carter Caves, but in some examples the eyes were connected by a narrow, black band.

Specimens from Weyer's Cave and the adjoining Cave of Fountains were just like those in the Carter Caves, being white, with small, black eyes and dull, purple leaden antennæ and tarsi. Those in the New Market Cave were white, with black eyes and dark lead colored antennæ.

In One Hundred Dome Cave specimens said to have been collected one-quarter of a mile from the entrance were all dark, of the usual out-of door plumbeous color.

Remarks.—It is evident that the var. *pallidus* has been produced by the influence of its cave life. Var. *pallidus* occurs in a cave near Salt Lake, Utah, and the specimens do not differ from the bleached ones in the Kentucky and Virginia caves. The trunk becomes bleached, while the extremities of the antennæ and legs retain somewhat of the colors of the out-of-door form. None have been found without eyes. The shallowest caves, such as the ice-house cave, in Carter County, Kentucky, as well as the deeper ones, possess this variety. We also find the normal *plumbeus* in similar caves, though probably near daylight, but the inference that the pale bleached variety has been produced by want of light is a natural and the only possible one. It is proved by finding in Zwingle's Cave a slightly changed *plumbeus* associated with numerous *pallidus*.

Packard's types of his cave Collembola seem to be lost. They were not in the Museum of Comparative Zoölogy, Cambridge, Massachusetts, with the rest of his material when I searched for them about fifteen years ago, and Packard wrote to me that he did not know where they were. I have made efforts to obtain specimens of this form from collectors of cavernicolous species, but without success as yet.

Genus TRITOMURUS (Frauenfeld) Absolon.

Tritomurus v. Frauenfeld, 1854, p. 15.
Tritomurus Absolon, 1903, p. 94.

Hitherto only one species of *Tritomurus* has been known—*T. scutellatus*, a European cavernicolous species. I have, however, from California, several specimens that belong in the genus *Tritomurus*, as redescribed by Absolon.

TRITOMURUS CALIFORNICUS, new species.

Plate 41, figs. 15-17.

Color when denuded of scales, yellow, minutely dotted with black. Ocular patches black, small, irregular in form; eyes absent. Antennæ shorter than the body; first two segments yellowish, purple basally; third and fourth segments ringed with purple. Unguis tridentate or bidentate, the teeth being on the basal half of the inner margin (pl. 41, fig. 15). Unguiculus without teeth. Fourth abdominal segment slightly longer than the third. Dental spines sixteen to eighteen; proximal spines in two series (pl. 41, figs. 16, 17); formula 7–9, **1**/2–3, **1**, 1–3, **1**, 2, **1**. Mucrones with four or five intermediate teeth. Length, 3 mm.

Described from six cotypes; Santa Clara County, California, C. F. Baker.

This form may easily be mistaken for a species of *Tomocerus* until close examination shows the absence of tenent hair, tibiotarsal suture, and eyes. In one small specimen a knobbed tenent hair was present on one of the legs, and its form was like that of *Tomocerus*. My formula for the dental spines doubtless does not express the entire range of variation, as it is based on an examination of only six specimens.

The single European species of *Tritomurus* lives in caves. In regard to the habitat of this Californian species, however, I have no data as yet.

Cotypes.—Cat. No. 16263, U.S.N.M.

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EXPLANATION OF PLATES.

PLATE 40.

Fig. 1. *Tomocerus flavescens*, var. *separatus*, claws, × 290.
2. *Tomocerus flavescens*, var. *separatus*, spines of left dens, × 190.
3. *Tomocerus flavescens*, var. *americanus*, claws, × 440.
4. *Tomocerus flavescens*, var. *americanus*, spines of right dens, × 214.
5. *Tomocerus flavescens*, var. *arcticus*, claws, × 440.
6. *Tomocerus flavescens*, var. *arcticus*, spines of left dens, × 223.
7. *Tomocerus bidentatus*, claws, × 514.
8. *Tomocerus bidentatus*, spines of right dens, × 223.

PLATE 41.

Fig. 9. *Tomocerus vulgaris*, claws, × 290.
10. *Tomocerus vulgaris*, spines of left dens, × 275.
11. *Tomocerus vulgaris*, right mucro, × 275.
12. *Tomocerus minor*, claws, × 308. An accessory tooth is shown on the unguiculus.
13. *Tomocerus minor*, spines of left dens, × 214.
14. *Tomocerus minor*, spines of right dens, × 223. Accessory spines are shown.
15. *Tritomurus californicus*, claws, × 398.
16. *Tritomurus californicus*, spines of right dens, × 248. Three of the spines are wanting.
17. *Tritomurus californicus*, arrangement and relative sizes of dental spines as indicated by their sockets, × 248.